ILRS SLR Mission Support Request Form
Retroreflector Information

(revised February 16, 2009)

Satellite name : STSAT-2A & 2B (Science and Technology SATellite-2, Two Satellites)

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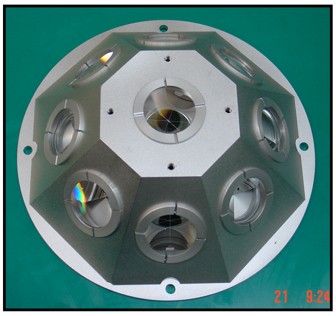
A prerequisite for accurate reduction of laser range observations is a complete set of pre-launch parameters that define the characteristics and location of the LRA on the satellite. The set of parameters should include a general description of the array, including references to any ground-tests that may have been carried out, array manufacturer and whether the array type has been used in previous satellite missions. So the following information is requested:

1. **Array type (spherical, hexagonal, planar, etc.), to include a diagram or photograph:**
   LRA consists of 9 corner cubes and symmetrically mounted on a hemispherical surface with one nadir-looking corner cube in the center and surrounded by an angled ring of eight corner cubes like Shunzhou-IV, ERS-1 & 2, Envisat, ALOS, GFO-1, Jason-1, and ADEOS-2.

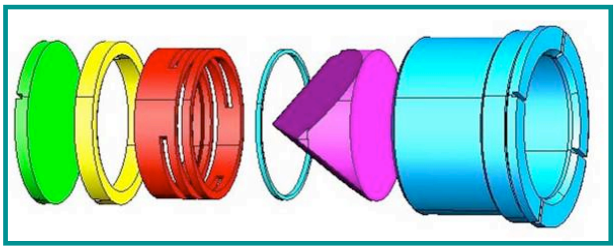


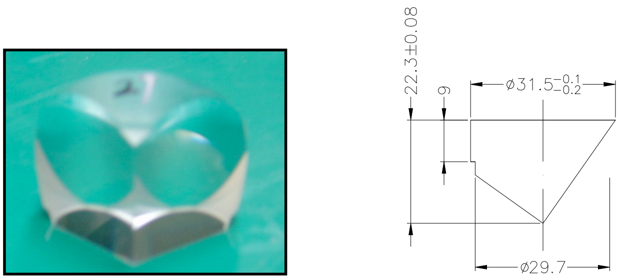
Laser Retroreflector Array Configuration for STSAT-2

2. **Array manufacturer:** STSAT-2A was manufactured by Shanghai Observatory in China and corner cubes for STSAT-2B were manufactured by Shanghai Observatory and others were manufactured by KAIST.

3. **Link (URL or reference) to any ground-tests that were carried out on the array:** Ref. to "*Laser Retroreflector Array Development for STSAT-2*" in "Targets, Signatures and Biases" session of 16th International Workshop on Laser Ranging.

4. **The LRA design and/or type of cubes was previously used on the following missions:**
   The LRA design for STSAT-2 is similar with shapes previously used such as Shunzhou-IV, ERS-1 & 2, Envisat, ALOS, GFO-1, Jason-1, and ADEOS-2.

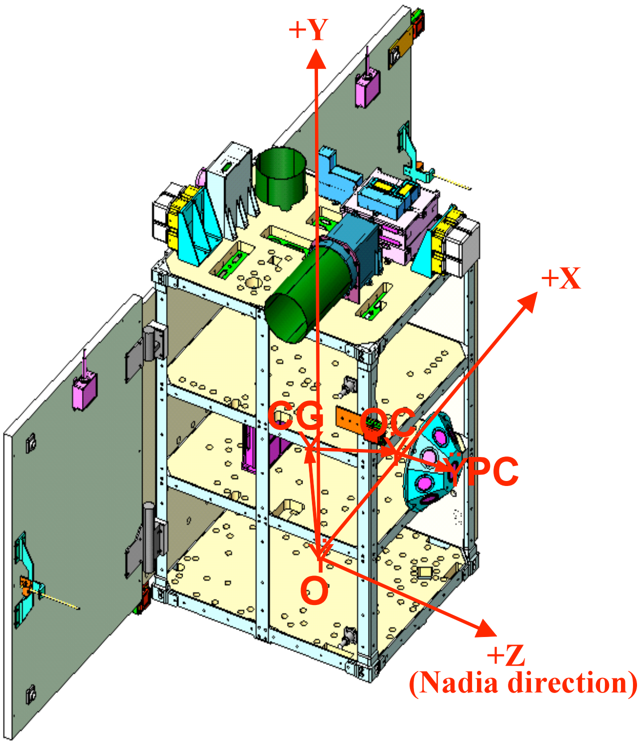




Assembly Configuration of the corner cube

For accurate orbital analysis it is essential that full information is available in order that a model of the 3-dimensional position of the satellite centre of mass may be referred to the location in space at which the laser range measurements are made. To archive this, the 3-D location of the LRA phase centre must be specified in a satellite fixed reference frame with respect to the satellite's mass centre. In practice this means that the following parameters must be available at mm accuracy or better.

5. **The 3-D location (possibly time-dependent) of the satellite's mass centre relative to a satellite-based origin:**
   O is satellite-based origin, and CG the satellite center of gravity.
   Vector C is from satellite-based origin to the satellite center of gravity.
   C = (-7.6, 381.4, 1.9)mm in the STSAT-2A and (-0.18, 412.16, 0.03)mm in the STSAT-2B.



Phase center configuration of LRA

6. **The 3-D location of the phase centre of the LRA relative to a satellite-based origin:**

   O is satellite-based origin, and PC the phase center.

   Vector L is from the satellite-based origin to the LRA mass center.

   Vector PC is from the satellite center of gravity to the phase center of retroreflector array.

   L = (-0.34, 381.92, 310.98)mm

   The plane of the front faces of the cubes is +35.52mm in the Z direction from the LRA mass center.

   For the Nadir-facing cube, the phase center is -h×n in the Z direction from the plane of the front faces of that cube.

   For the STSAT-2 cubes, h=22.3mm and n=1.464. So the phase center for the Nadir cube is -32.65mm in Z direction. So Z-component of array phase center for that cube is +2.87mm from LRA mass center, but will vary at the level of a few mm depending upon which of the other cubes are visible from the tracking station . However, ignoring that effect here, and defining vector L' as the vector from the satellite-based origin to the phase center of the retroreflector array, we have

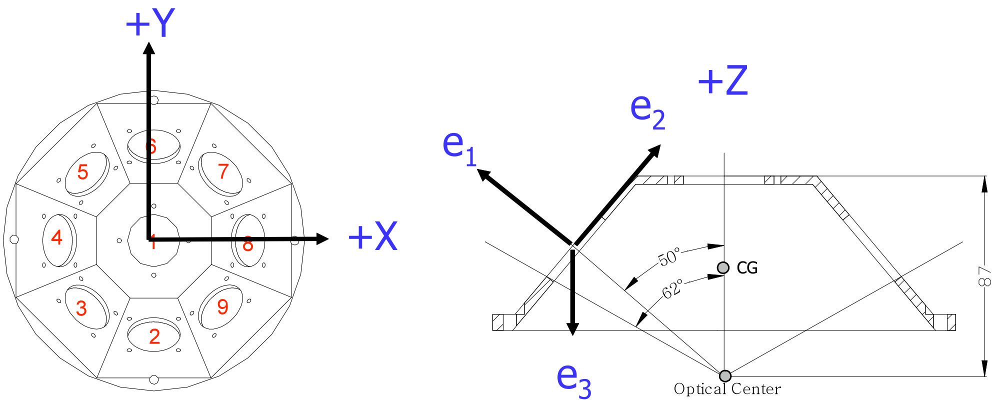
L' = (-0.34, 381.92, 313.85)mm

Finally, the vector PC from the satellite center of gravity to the phase center of the retroreflector array is PC=L'-C.

So PC = (7.26, 0.52, 311.95)mm in the STSAT-2A and (-0.16, -30.24, 313.82)mm in the STSAT-2B in satellite fixed frame.

However, in order to achieve (6) if it is not directly specified (the ideal case) by the satellite manufacturer, and as an independent check, the following information must be supplied prior to launch:

7. **The position and orientation of the LRA reference point (LRA mass-centre or maker on LRA assembly) relative to a satellite-based origin:**
   OC is the optical center of LRA and the location of OC is -0.5mm(x), 382mm(y), 269.5mm(z).
8. **The position (xyz) of either the vertex or the centre of the front face of each corner cube within the LRA assembly, with respect to the LRA reference point and including information of amount of recession of front faces of cubes:**
   The LRA reference point (RP) is the LRA optical center. The positions from optical center to the center of the front face of each corner are as follows.
   (1) Position of No 1 : (0, 0, 87)mm
   (2) Position of No 2 : (0, -66.65, 55.92)mm
   (3) Position of No 3 : (-47.13, -47.13, 55.92)mm
   (4) Position of No 4 : (-66.65, 0, 55.92)mm
   (5) Position of No 5 : (-47.13, 47.13, 55.92)mm
   (6) Position of No 6 : (0, 66.65, 55.92)mm
   (7) Position of No 7 : (47.13, 47.13, 55.92)mm
   (8) Position of No 8 : (66.65, 0, 55.92)mm
   (9) Position of No 9 : (47.13, -47.13, 55.92)mm



LRA Dimension

9. The orientation of each cube within the LRA assembly (three angles for each cube):

   Three dihedral angles of corner cube are defined by $\delta 1, \delta 2, and\, \delta 3$ and three dihedral angles for each cube are as following.

   in STSAT-2A,

   (1) No 1 : 1.78, 1.56, 1.30 sec

   (2) No 2 : 1.08, 1.09, 2.11 sec

   (3) No 3 : 1.29, 1.42, 1.74 sec

   (4) No 4 : 1.54, 1.47, 1.54 sec

   (5) No 5 : 1.90, 1.25, 1.11 sec

   (6) No 6 : 1.65, 1.73, 1.38 sec

   (7) No 7 : 1.76, 1.13, 1.55 sec

   (8) No 8 : 2.03, 1.57, 0.83 sec

   (9) No 9 : 1.67, 1.14, 1.84 sec

   in STSAT-2B,

   (1) No 1 : 1.78, 1.56, 1.30 sec

   (2) No 2 : 1.08, 1.09, 2.11 sec

   (3) No 3 : 1.29, 1.42, 1.74 sec

   (4) No 4 : 1.54, 1.47, 1.54 sec

   (5) No 5 : 1.90, 1.25, 1.11 sec

   (6) No 6 : 1.65, 1.73, 1.38 sec

   (7) No 7 : 1.76, 1.13, 1.55 sec

   (8) No 8 : 2.03, 1.57, 0.83 sec

   (9) No 9 : 1.67, 1.14, 1.84 sec

10. The shape and size of each corner cube, especially the height: The diameter of the corner cubes is 31.5mm and the height of the corner cubes 22.3mm. Refer to “Configuration of the corner cube.
11. The material from which the cubes are manufactured (e.q. quartz): Fused Silica
12. The refractive index of the cube material, as a function of wavelength λ (micron): _The refractive index of the corner cube is 1.46 at 532nm.
13. Dihedral angle offset(s) and manufacturing tolerance: The dihedral angle offset is +1.5 sec in the STSAT-2A and +1.2 sec in the STSAT-2B and the manufacturing tolerance is ±0.5 sec in the STSAT-2A and ±0.2 sec in the STSAT-2B.
14. Radius of curvature of front surfaces of cubes, if applicable: Not applicable
15. Flatness of cubes’ surfaces (as a fraction of wavelength): λ/20
16. Whether or not the cubes are coated and with what material: No coating

An example of the metric information (points 5-8 above) that should be supplied is given schematically below for the LRA on the GIOVE-A satellite. Given the positions and characteristics of the cubes within the LRA tray (points 8-12), it is possible to compute the location of the array phase centre. Then given the C and L vectors (points 5 and 7) it is straightforward to calculate the vector from the satellite’s centre of mass (CoM) in a spacecraft-fixed frame to the LRA phase centre. Further analysis to derive the array far-field diffraction patterns will be possible using the information given in points 8-16.